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Technical Lesson 55

INTERFERENCE ELIMINATION

Radio interference may be classified under six headings, as follows:

1. Broadcast transmitters radiating energy on the same, or nearly the same, wavelength.
2. Nearby powerful broadcasting stations.
3. A neighboring receiver in an oscillating condition will act as a miniature transmitter.
4. Electrical atmospheric disturbances arising in space and commonly known as atmospherics, or static, cause interference.
5. Faulty parts of a receiver at times will give rise to disturbing noises.
6. Lastly, we have interference which originates from commercial electrical machines, power lines, trolley cars, elevated systems, subways, home electrical appliances, and electrical apparatus used in the professional fields, such as X-ray and violet ray equipment.

The term interference, in the broad sense of the word, means, that when listening to a broadcast program, sounds are heard from the loudspeaker which are not a part of the desired signal. These sounds form a disturbing background to an otherwise enjoyable program and may appear in different forms. They are usually unintelligible sounds which may be described as crackling, sputtering, squealing or queer whirring and buzzing noises. The cause of many of these disturbing sounds that detract from the radio program are readily understood, while the cause of others is recognized usually only by the service man who has actually become experienced in this phase of the work.

Interference of the nature outlined under the first heading may be due to transmission problems or to lack of selectivity in the receiver. By transmission problems is meant the possible faults in the frequency control devices of the transmitting equipment, or where two stations are operating on or about the same frequency at the same time, or on frequencies not separated by at least 10 kilocycles.

Conditions of this kind, however, are rapidly disappearing due to the work of the Radio Commission, assisted by the officials of broadcasting stations. Cooperation between officials of broadcasting stations and the Commission results in either a reallocation of wavelengths, a more active watch being maintained on frequency control devices, or some equally satisfactory plan is put into practice whereby this particular form of interference is eliminated.

A shrill whistle which forms a background to the program being received is sometimes caused by broadcasting stations transmitting on adjacent frequencies less than ten kilocycles apart. When the proper separation of frequencies is not maintained, and the receiver is tuned to either of the stations operating under such conditions, two currents of different frequency pass simultaneously through the receiving circuit producing an entirely new frequency which is audible. The production of a third frequency, or beat note, when one frequency is superimposed upon another, is called "heterodyning." This phenomenon explains the meaning of the expression, "the heterodyning of two stations."

From what has just been said, you can readily realize that the service man is not expected to correct troubles of this nature. These difficulties must be removed by the engineers of the stations at fault.

The selectivity of the receiver plays an important part in eliminating interference coming under this classification. A selective receiver possesses characteristics which enable it to select any one of a series of frequencies, allowing the selected frequency to pass through the circuit, but excluding the undesirable ones.

At times the sensitivity of a receiver affects its selectivity. Receivers which are extremely sensitive to a very weak incoming signal usually reproduce powerful signals from the loudspeaker. Hence, a receiver of this design in practically all cases will make an interfering signal audible under certain conditions, where a less sensitive receiver, delivering less loudspeaker volume, will not reproduce the interference. This means that the interfering signal may be present in the less sensitive receiver but it is reduced below the point of audibility.

The sensitivity of most of the modern receivers is governed by means of a volume control which functions independently of the selectivity control, therefore, the procedure to adopt when interference is experienced with an extremely sensitive receiver is to reduce the sensitivity of the receiver by the volume control.

The fundamental principle upon which the selectivity of all receivers is based is the incorporation of inductance and capacity in the circuit. The coils form the inductance, and the condensers provide the major capacity. Such a circuit will present a minimum of opposition (reactance) at a frequency to which it is tuned; which means, that by so proportioning the values of inductance and capacity (or vice-versa) a predetermined frequency can be made to pass through the circuit with the least possible opposition. This results in maximum voltage or current available at this particular frequency.

With a circuit thus tuned to a predetermined frequency, any other frequency above or below the specified frequency will find reactive forces at work which will cause a greater attenuation, that is, dwindling or dying out of currents at frequencies other than those which the circuit is tuned to pass. It is upon these principles that the radio broadcast receiver is designed.

A receiving circuit, however, which incorporates only one tuned circuit would prove inadequate in providing fine selectivity because of present

day interference problems. The current response produced by the voltage of a frequency above or below the desired frequency, but close to it, will be less than the frequency to which the circuit is tuned, but it may not be small enough to be absorbed to the extent that its interfering effects will be eliminated.

The necessity of employing methods that will increase the selectivity of the receiver must be put into practice. This is accomplished by employing a series of tuned circuits, commonly spoken of as "tuned radio frequency stages," each stage coupled to the other. By this system the desired frequency is selected and the signal energy, together with the energy of the undesirable frequency, is made to pass through successively tuned circuits. The desired signal energy finds its way through each of the circuits with little or no difficulty because, by adjusting the variable condenser, the ratio of inductance to capacity can be altered to the extent that the least possible reactance (opposition) is offered to the radio frequency currents of the frequency to which the circuit is adjusted (tuned). But the currents of the undesirable frequency are materially weakened as they pass through each successive stage until a point is reached where they become too weak to produce audible response in the loudspeaker. Because of this the selectivity of the receiver is improved.

Receivers now used for radio broadcast reception may be classified as follows:

1. Those which utilize one stage of tuned radio frequency and variable regeneration.
2. Those which utilize three stages of tuned radio frequency without the effective balancing of coupling between the radio frequency stages, each stage, however, being heavily damped by what is termed the "grid suppressor" method which prevents oscillations between the R.F. circuits.
3. Those which utilize three radio frequency stages without the grid damping resistors and employing more or less complete balancing of inter-stage coupling between the radio frequency stages.
4. Receivers in which both radio frequency and intermediate frequency tuning stages are utilized.

Receivers under classification (1) are more selective than receivers consisting of a detector and audio frequency amplification only. Class (2) has a higher degree of selectivity than class (1), and greater selectivity may be attained with class (3) and (4) than either of the preceding types.

Individual receivers, however, may vary relative to the degree of selectivity they are supposed to possess regardless of their design, and especially when located in close proximity to a powerful broadcasting station. The types of receivers subject to interference because of their location to a nearby powerful broadcast transmitter are those mentioned under class (1), and others not classified, such as the single circuit type, and some of the home constructed sets. The majority of receivers outlined under (2), (3) and (4) are usually factory products, and little or no trouble will be experienced with them.

Occasionally, however, any receiver will vary as to its capability of selecting a particular frequency, to the exclusion of others, especially when located close to a powerful transmitter. When this is the case, a device known as a "wave trap" may be employed to overcome the difficulty.

A wave trap is a device designed to reduce or eliminate radio interference when this interference is caused by stations other than the one desired. There are two principle types of wave traps; one is known as the "absorption" type, and the other the "rejector" type.

A diagram of the absorption type appears in Figure 1. As shown, there are two coils wound on a three inch form in such a manner that inductive coupling is provided between the two windings. The small coil consists of from 5 to 8 turns of No. 22 double cotton covered wire closely wound. This coil is connected directly in the antenna as shown in the Figure.

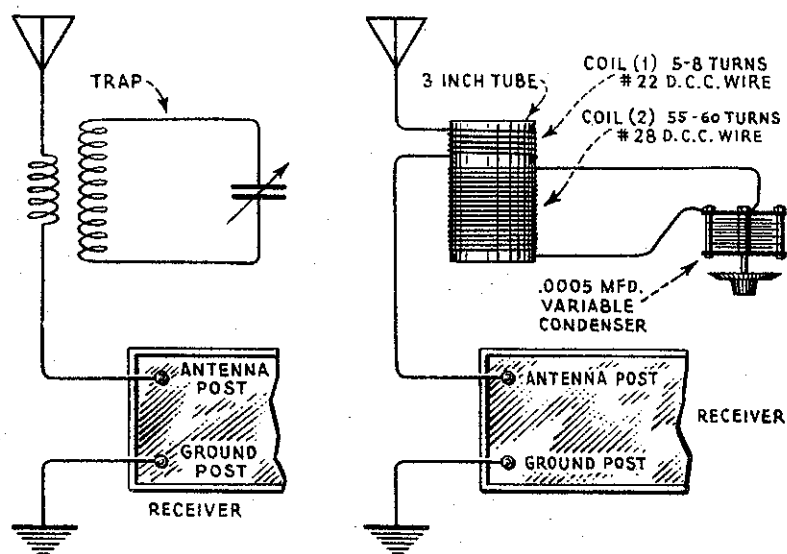


Figure 1

The large coil is wound with 55 to 60 turns of No. 28 double cotton covered wire. A 0.0005 mfd. variable condenser is connected across this coil.

The degree of coupling between these windings affects both the elimination of the interfering signal and the position of the tuning controls of the receiver. To obtain close coupling, wind coil 1 close to coil 2, thus decreasing the distance between them. This will materially aid in eliminating the interfering signal but it has a greater effect upon the position of the tuning controls of the receiver.

To secure loose coupling, wind coil 1 and 2 in such a manner that an open space separates the two windings. The results obtained will now be the reverse of those when close coupling was employed.

The correct spacing to allow between the two coils so that a satisfactory elimination of the interfering signal is secured (and at the same time affecting the least change in the receiver controls from their normal tuning

position) is found by a little experimenting and, when once found, it can be made permanent.

To use the wave trap set the condenser to zero, tune the receiver until the interfering signal is received with maximum volume, then rotate the trap condenser until the undesired signal is reduced to minimum strength, carefully readjust the receiver controls to the interfering signal the second time and readjust the trap condenser until the undesired signal entirely disappears or is reduced to minimum intensity. The wave trap control is now left in this position as long as this particular frequency is to be eliminated. The receiver is operated in the usual way to select the desired signal.

The wave trap functions as a resonant circuit in which alternating current is flowing. By varying the capacity of the variable condenser the capacitive reactance (condenser opposition) is made equal to the inductive reactance (coil opposition) thus cancelling out these two forms of opposition which oppose current flow at a particular frequency. The circuit is then reduced to one possessing only ohmic resistance, thereby allowing the maximum current

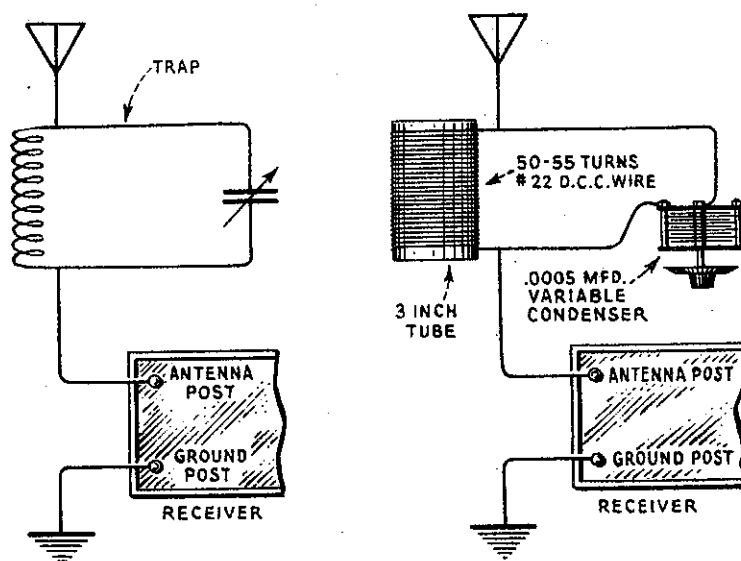


Figure 2

flow. The purpose of the wave trap in Figure 1 (the absorption type) is to absorb the particular frequency to which it is tuned (and which is an undesired frequency) so that little or none of it will reach the receiver.

A view and schematic diagram of the rejector type wave trap is shown in Figure 2. It is composed of a three inch tube on which is closely wound 50 to 55 turns of No. 22 double cotton covered wire, and a 0.0005 mfd. variable condenser. The condenser is connected in parallel with the coil.

The operation of this wave trap is identical to the type just described and it has practically the same effect upon the tuning of the receiver as the former type.

The circuit consists of an inductance (coil) and capacity (condenser) connected in parallel. This combination, in turn, is connected in series with the antenna. By means of the variable condenser it is possible to adjust the trap circuit to resonance with the frequency of the interfering signal. When this condition is obtained the trap circuit offers the least impedance to the interfering signal frequency and "by-passes" it from the main antenna circuit, thereby allowing it to flow back and forth between the condenser and coil. In this manner it prevents the undesirable frequency from reaching the receiving circuit. This arrangement is most successful when the antenna is exceptionally long, or where the receiver is connected to a poor ground. The wave trap, therefore, can be advantageously used in conjunction with the more or less non-selective types of receivers which are located near broadcasting stations.

Oscillating Receivers. Regeneration is the process of feeding back energy from the plate to the grid in a vacuum tube circuit. This is permissible and in fact an asset to a receiver. When carried beyond a certain point, however, regeneration in the proper sense of the word ceases, and the receiving circuit becomes an oscillating circuit. As such it is a generator of high frequency oscillations; in this condition it is in reality a transmitter.

The power of the radiated energy from an oscillating receiver is weak when compared to that of a broadcasting transmitter, yet it radiates sufficient energy to occasionally destroy a broadcast program being received by a neighboring set if the two sets are tuned to the same program. Manufacturers of modern receivers employing a regenerative detector always design the circuit so that oscillations of this nature are prevented from reaching the antenna, but some of the earlier types of receivers were not designed to take care of such a condition. Many of these older sets are still in use and interference caused as a result of their improper operation should be recognized immediately by the service man.

If a shrill whistle is heard, at times breaking into the program with a violent chirp and at other times gradually rising and falling in pitch when the controls of the receiver are not being manipulated, it is a fair indication that someone in the immediate neighborhood is operating a receiver in an oscillating condition.

In the majority of cases the listener-in does not know when he is obtaining the best possible results with the particular receiver he is operating, and in an endeavor to get maximum volume he forces the set beyond the best operating point, setting the circuit into oscillation. There is very little that one can do to eliminate this type of interference other than to locate the owner of the offending set and inform him that he is creating interference in his effort to obtain greater volume.

Atmospheric Interference. Static! How often we have heard that word. Its tendency to interrupt, and in many instances entirely ruin radio broadcast reception, is not an uncommon occurrence. "Atmospherics" and "Strays" are synonymous expressions for "static." All three of these words refer to the roaming electrical phenomena which are produced in nature. "Static" is a short way of saying "static electricity," and because static electricity concerns us at this time, we should know something more about it.

The atmosphere of the earth is filled at all times with what is termed "charges of free electricity." This free electricity is static electricity. Where it comes from no one definitely knows. Many opinions have been expressed in an attempt to arrive at a satisfactory explanation of its exact origin; it still remains, however, one of the secrets of nature. Many opinions are advanced, therefore, that must be given due consideration.

A most vivid manifestation of the presence of static charges in the air is during thunder storms. The lightning seen at such times is the discharge between the clouds and earth (and between cloud and cloud) of great accumulations of static electricity. A discharge of this nature is immediately made known by a characteristic crashing noise being emitted from the loud-speaker. We say this noise is caused by static.

Fine weather may prevail at the location of the receiver but the lightning discharges of a distant storm will still have its effect upon the receiver even though it is thousands of miles away.

Why the receiver is affected by static is because of the discharge of static accumulations which set up an electromagnetic disturbance in the atmosphere. A thunder storm acts as the greatest producer of this form of electrical disturbance.

Carriers of Static Charges. When listening-in to a program during a rain or snow storm it is not an uncommon occurrence to receive a slight hissing sound. The rain drops and snow flakes are carriers of minute static charges and, as they come in contact with the antenna wire, they impart this charge to the aerial system. Each of these charges sets up a minute current which passes through the receiving circuit to earth, producing a slight oscillatory impulse in the tuned circuit which, in turn, is emitted from the speaker as a hiss.

In dry hot weather the air is filled with small dust particles. These are also carriers of static charges which, on striking the antenna, give up an accumulated charge and produce interfering effects.

Other characteristic noises heard from the reproducing unit of a receiver, because of the effect of charged particles striking the antenna, are irregular "clicking" sounds or crashes resembling that which would be heard by throwing pebbles against a wall.

Other Sources of Atmospheric Disturbance. It is not uncommon, since radio broadcasting became popular, to read accounts of the "Northern Lights" (Aurora Borealis) and its effect upon radio broadcast reception. Why the Aurora Borealis should affect radio reception is not difficult to understand when we accept the scientific reasoning that is set forth as a possible explanation of the phenomenon.

Bodies in space are considered to be one of the sources of electrical phenomena affecting radio reception. This is especially true of the sun which may be thought of as an enormous generator, and which not only radiates heat and light waves, but electrical waves as well. The one particular form of electrical phenomenon in which we are interested, is one which is visible to us on earth; namely, the Northern Lights. Because of the tremendously high temperature of the sun, a continual forming, combining, and decomposing of

its elements is in progress, and the atmosphere surrounding this body is considered to be of a gaseous nature. Heated gases originating within the body of the sun rise to great heights and in moving away they expand and cool. In cooling they naturally become heavier than the heated gases below them and they then have the tendency to fall back toward the surface of the sun. An opening may occur at a lower level in the sun's atmosphere, or perhaps at some spot on the surface of the sun into which these cooled gases sink. As they fall back they increase in velocity, rushing toward the openings at tremendous speeds until finally they become stupendous cyclonic storms embracing areas thousands of miles in diameter. This whirling body of gas rushing into the sun is considered to be charged with electricity and, in its downward motion, it sets up a magnetic disturbance of great proportions; so great in fact that they extend millions of miles into space. When a magnetic force of this nature emanates from the sun, and the earth is in a line with this force, it may make its presence known by the effect it produces; namely, the Aurora Borealis.

The lights of the Aurora Borealis are considered to be a condition of ionization of the gases in the earth's atmosphere. This does not take place on the surface of the earth but at high altitudes called the "Auroral" region. This region is perhaps two or three hundred miles in height, at which point the gases of the earth's atmosphere are very low in pressure; i.e., rarefied.

The earth, in moving about its orbit at a speed of over 1000 miles a minute, passes occasionally through one of these magnetic fields produced by disturbances on the sun. The rarefied gases of the auroral region then perform much like a closed conductor being forced through a magnetic field. An electromotive force is produced and current flows through the gas particles causing it to glow, resulting in a brilliant display of great ribbons of light across the heavens. This glow appears only at the heights in the atmosphere where the pressure is of the value that will cause ionization to take place.

The magnetic force, however, extends to the earth and, as the earth rushes through one of these magnetic storms, current is induced into all conducting mediums, such as antennas, telephone and telegraph lines, and so on. These, in turn, produce the characteristic clicks called "Static." The effect on an individual antenna may not always be so pronounced, but in the case of telephone and telegraph lines, which extend for miles across the country, the induced voltage is often of sufficient magnitude to completely disrupt normal operation for several hours.

From the foregoing paragraphs it is understood that electrical disturbances which affect the reception of radio broadcast programs originate from different sources, and they create interference on all wavelengths.

A tuned radio circuit cannot entirely eliminate these disturbances but it may greatly reduce them. If the interference is present on the same wavelength as the signal being received, there is no way to prevent it from passing through the circuit and causing audible response in the loudspeaker.

Many devices have been invented in an attempt to eliminate static, but so far the only practical method of reducing its effects is by employing loosely

coupled circuits and short antennas, or by using a loop. Static eliminators which have produced encouraging results are so elaborate as to prohibit their general use.

Noise Originating in the Receiver. Noises which interfere with a broadcast program are often called static, when in reality, they originate in parts of the receiver. It is much better to classify this kind of interference as noise, because static, strictly speaking, is the result of the antenna system absorbing electrical charges present in the atmosphere. Receiver noises are due to faulty units of the set, its accessories, poor design, and careless construction work.

Harsh, Scratchy, and Crackling Noises. If the "on" and "off" switch becomes worn, the result will be a continual series of scratchy sounds. The worn contacts of the switch are subject to minute vibrations which may often cause the filament circuit to be opened and closed. A loss in sound intensity also may result, due to poor or dirty contacts in the switch parts. A change of resistance in the filament circuit is caused by badly worn or dirty switch contacts.

Rotor plates of variable condensers may become bent because of abuse and, when rotated, they will short circuit the condenser by making contact with the stator plates. When this occurs, a click or rasping sound will be heard from the loudspeaker.

Faulty flexible leads of a variometer will produce crackling noises when the variometer is rotated.

All binding posts screws or terminal strips should be inspected and, when found to be loose, they should be tightened so that the wire ends or "spade" terminals from the batteries will not shift position due to vibration.

Broken plate leads in the receiver will produce loud clicking noises. Poor "B" battery connections will produce the same effect.

Storage battery terminals often become corroded. The acid salts accumulating at these terminals is a source of trouble, sometimes completely preventing the flow of current. The increased resistance to the circuit caused by storage battery terminal corrosion will cause a faint high pitched whistle in some receivers.

Corroded soldered joints are producers of undesirable noise.

Excessive dirt or dust accumulations about open wiring, between condenser plates, and on the spring contacts of tube sockets will often be the source of crackling sounds.

Filaments of inferior tubes will often produce noise after they have been in operation for a short time.

Poorly designed and cheap grid leaks are very likely to give considerable trouble.

"Popping" which occurs at more or less regular intervals may be due to a grid leak of wrong value; try replacing with various values until the popping ceases.

Howling. Howling may occur when the receiver cabinet or any of its controls are touched, or it may even occur when no one is near the receiver. This is caused usually by a microphonic tube. The howl caused by a microphonic tube is principally a problem of mechanical vibration. As you know, "sound" is the result of vibrating air particles and the vibrations of a loudspeaker set the air about the speaker into complex wave motions. If the speaker is resting on a table, vibrations are imparted to the table top. The table top acts as a conductor for these vibrations and transmits them to other objects upon the surface of the table.

The vibrations from the loudspeaker may find their way to the tubes through the air, or by way of the table top. With the speaker isolated from the support holding the receiver, opening the lid of the cabinet will often result in this howl, which will cease when the lid is closed. It is clear in a case of this kind that the vibrations are reaching the microphonic tube by way of the air.

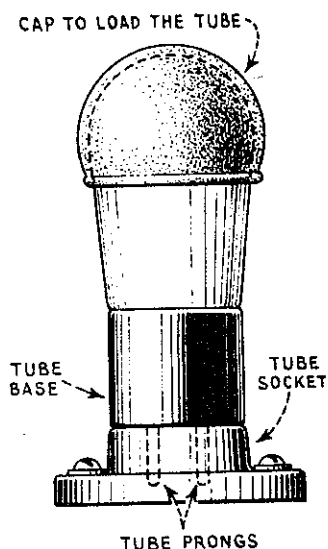


Figure 3

Consider another case where the loudspeaker is resting upon the same table supporting the receiver. As soon as the set is placed in operation the howl starts; by removing the speaker from the table the howl ceases. This time it is evident that the vibrations were being transmitted from the loudspeaker directly to the tubes by way of the table top cabinet, and the tube sockets. A remedy which is very often successful in preventing microphonic tube howl is to "load" the tube with a heavy cap. This cap is slipped over the top of the tube as shown in Figure 3. An arrangement of this kind prevents the tube from moving freely. It is still free to swing when vibrations strike it, but not to the same extent. Spring sockets also tend to absorb shocks and

vibrations which would otherwise cause the tube elements to vibrate. The vibration period of the tube, when weighted down with a heavy cap, is perhaps only seven or eight times a second. A vibration pitch of this magnitude is far below the audibility range and will not be heard in the loudspeaker.

The new a-c. tubes rarely, if ever, show microphonic tendencies and very little trouble of this nature should be experienced in the new sets.

Vibration is indirectly the cause of this microphonic trouble but not the actual cause, for why should it occur with one tube and not another? A microphonic tube is simply an ordinary tube in which one or more of the elements are loosely mounted when assembled. It is essential that all of the tube elements (grid, plate, and filament) be so mounted and supported that a rigid fixed position is maintained between them. If any of the elements move, the spacing between them is changed and, as a result, the normal characteristics of the tube are changed.

For example, a tube designed to have a low voltage amplification factor is so constructed that the grid and plate elements are mounted close together, while in a tube designed to have a high voltage amplification the grid is

placed close to the filament and some distance from the plate. If the sound vibrations cause the tube to move, the loose elements will also move. The distance between these elements consequently are changed and the plate current will follow these changes. The plate current changes are then magnified by the amplifying stages following the microphonic tube and reproduced in the loudspeaker as a swinging howl, varying in pitch as the vibration pitch of the tube changes. In some cases interchanging the tubes in their sockets will eliminate this trouble. A tube having extreme microphonic tendencies should never be used.

Inductive Interference. When a spark discharge occurs in an electrical circuit, interference is the result. We term this, "inductive interference."

When it is realized that a small electric spark created by electrical machines, or apparatus, produces electrical waves of various frequencies, it is apparent at once that the antenna system of a radio receiver will intercept such waves, and they will be conveyed to the receiver in precisely the same manner as the high frequency energy radiated from a broadcast transmitter. A spark less than a centimeter in length is a possible source of this type of interference and we do not have to look far to find innumerable types of apparatus which are capable of doing this very thing. To list every conceivable kind of machine or piece of apparatus that might come under such a classification would require a huge volume. The following list, however, is sufficient to give a comprehensive idea of where to look for possible causes of interference.

(1) Automatic oil burners, (2) Electric washing machines, (3) Electric refrigerators, (4) Electric warming pads, (5) Clapper switches on elevator controls, (6) Electric vibrators, (7) X-ray machines, (8) Motors operating dental equipment, (9) Violet ray apparatus, (10) Bare power lines swinging against tree branches, (11) Telephone ringers, (12) Electric door bells, (13) Trolley cars and elevated systems, (14) Farm lighting systems, (15) High voltage laboratory equipment, (16) Vacuum cleaners, (17) Electric sign flashers, (18) Defective lamp sockets, (19) Rapidly moving leather belts, (20) Buzzers, (21) Electric player pianos, (22) Rotary convertors of motion picture equipment, (23) Defective electric flat iron plugs, (24) Defective arc lamps.

Sparking is caused by the interruption of a current flow during the operation of certain kinds of electrical apparatus, especially with those designed to operate with a make and break mechanism. Electric motors of all kinds are possible causes of interference.

Thermostatic control devices, bell ringing apparatus, and sign flashers are sources of considerable trouble.

The first instance produces sparking, generally because of the poor contact made between incorrectly fitted brushed and the revolving commutator segments, or collector rings.

Thermostatic devices cause interference because certain of its parts depend upon the "make and break" of the circuit to produce results that the apparatus is designed for.

Poor contacts, such as might occur in the connections of lamp sockets, flat irons, electric toaster input plugs, unsoldered or loosely made splices, the discharge or leaking of electrical energy to ground because of faulty insulators, are all possible sources of interference.

The high frequency energy transmitted by spark discharges becomes increasingly objectionable as the intensity of the spark increases. A sudden variation in the strength of current flowing in a circuit will cause what is known as a "surge," due to some fault in the circuit, which will result in wave motion of various frequencies being set up in the space surrounding the particular circuit. Power lines in which this trouble may exist act as antennas, and they assist in the radiation of an interfering wave of this nature which may travel great distances to either side of the actual location of the trouble. Disturbances of this kind are often difficult to cope with and special apparatus is required to trace it.

Elimination Procedure. To eliminate interfering electrical impulses, use is made of condensers and choke coils, or a combination of both. A unit of this kind is called a "filter." The construction of a filter unit is a simple matter and its installation is by no means difficult. Caution, however, should be exercised when connecting such a device to a power circuit. Make certain that the installation is made in compliance with the rules of the Board of Fire Underwriters. Fire hazards are to be avoided in all cases. Figures 4 to 9 are schematic diagrams showing various filter circuits.

Exact specifications relative to the capacity of the condensers, or to the inductance of the choke coils, are not shown in these diagrams because of the possible variations in the absolute values of these units when applied to different conditions.

In many cases where filters are called upon to eliminate interference a certain amount of study of the particular situation will be required. One or more of the various hook-ups shown in Figures 4 to 9, inclusive, may be employed. It may be necessary to substitute various values of capacity and inductance before the correct combination is found that will effectively produce the desired results.

The condenser used in any of the filter circuits shown, should be capable of withstanding a 1000 volt direct current test when connected across a 110 and 220 volt supply line.

The choke coils must be wound with the proper size and length of wire to give the reactance desired and to safely carry the current flowing in the circuit in which they are connected.

With the knowledge, then, that hard and fast rules cannot be given relative to definite values of condenser capacity and choke coil inductance, we can continue with a few specific cases in which approximate specifications are available and which will, in many instances, prove successful in curbing the interference.

When an investigation has been made and the defective electrical device has been located, the application of the filter unit is the next step. Figure 10

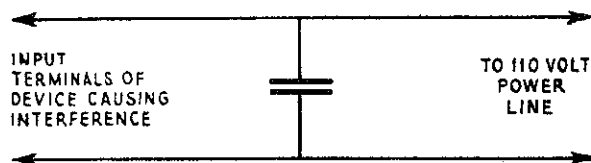


Figure 4

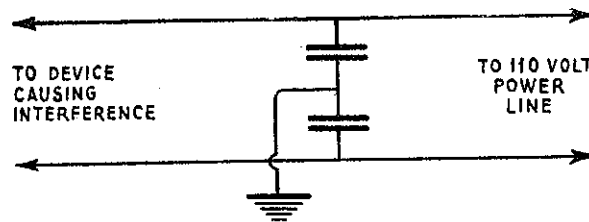


Figure 5

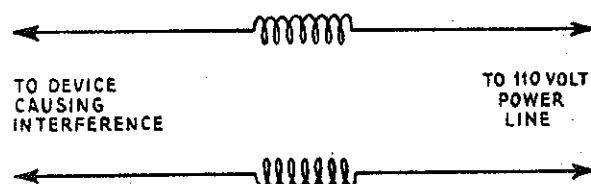


Figure 6

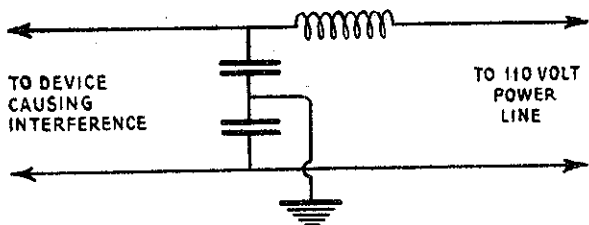


Figure 7

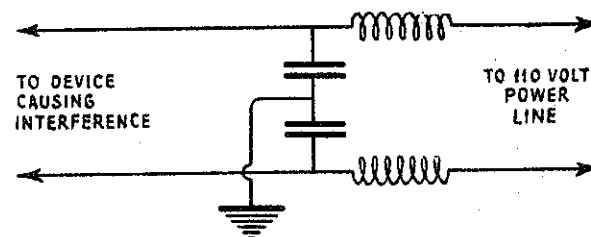


Figure 8

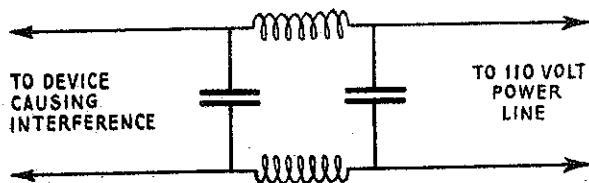


Figure 9

represents a device utilizing a small motor known as the universal type motor, that is, one which operates from either a-c. or d-c. A small 0.5 mfd. capacity condenser is shown connected across the motor input terminals.

Figure 11 illustrates a motor of the washing machine type equipped with a filter unit wired according to Figure 8; the condensers may be 0.5 to 1.0 mfd. capacity. The choke coils are wound with about 100 to 150 turns of insulated copper wire on a 2½ inch form, the size of the wire depending upon the current drawn by the motor. In installations of this kind it is possible that the filters shown in Figures 4, 5, and 7 may eliminate the interference, the capacity of the condensers remaining approximately the same. The choke of Figure 7 should have approximately the same number of turns of wire and of a size sufficient to carry the current drawn by the device to which it is connected. The inductance of any choke coil should be at least 1.5 milli-henrys.

Figure 12 shows an electrical heating pad. The thermostatic unit producing the interference is shown in Figure 13 a, b, and c, in a simplified form.

Heating pads have thermostatic current controls which are made up of two dissimilar metals, each having a different coefficient of expansion. The first

metal, we will say, expands more rapidly than the second, therefore, at a certain heat the rapid expansion of the first metal will force the contacts apart, in this way breaking the circuit as shown at "b." When sufficiently cooled the entire arm D drops back on contact E as shown at "a" and current again flows through the thermostatic alloy. Because of certain conditions, this arm D may open just far enough at times so that the least vibration will cause it to rapidly make a series of "makes" and "breaks" as shown at "c", and an arc will be drawn each time. It is this part of the device that causes interference from heating pads.

Figure 12 shows a 1.0 mfd. condenser connected as close to the thermostat as possible; i.e., at the socket connection of the twisted wires coming from the heating element of the pad.

Sign flashers are very numerous. A great many types have electrically driven mechanism which allows current to operate lamps arranged to intermittently spell words, and also to build up entire scenes. The controlling mechanism may be so designed as to flash instantaneously the entire message or scene that the sign is designed to present, or to build the message or scene up step-by-step by flashing letters or scenes successively, until the entire object appears.

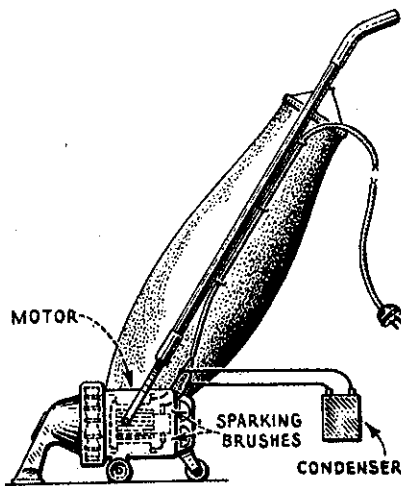


Figure 10

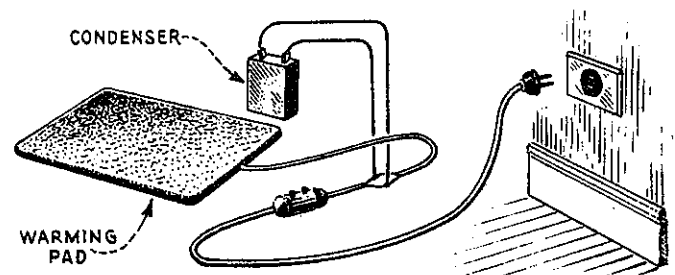


Figure 12

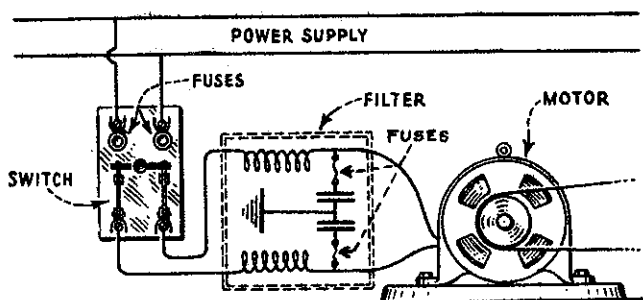


Figure 11

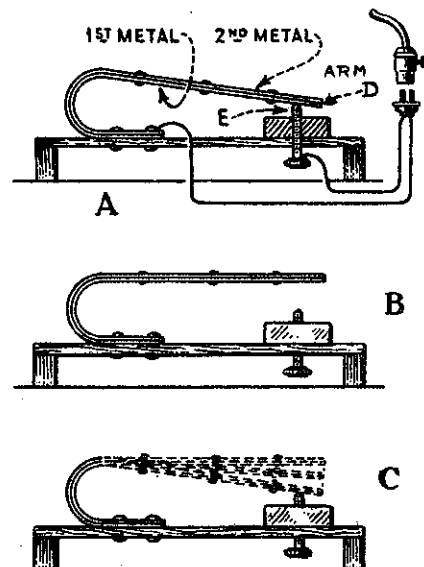


Figure 13

As a rule electrical signs of this type have all the control mechanism enclosed by a metal housing which is usually grounded to carry off interfering waves caused by sparking that occurs at the "make" and "break" of the current supplied to the sign lamps.

Another type which depends upon the thermostatic control is shown in Figure 14. Again we have the principle of an expanding metal. In this case, however, the metal "M" is heated by a coil "C" which opens the contacts "D". On cooling, contact is made again at D and the sign illuminates.

The condensers required may be of any capacity from 1.0 to 5.0 mfd., while the choke coil should consist of at least 250 turns of insulated wire on a form 3 inches in diameter and of a size sufficient to carry the current drawn by the lamps in the sign. In cases of this kind filter units as shown in Figure 8, employing two choke coils, may be required.

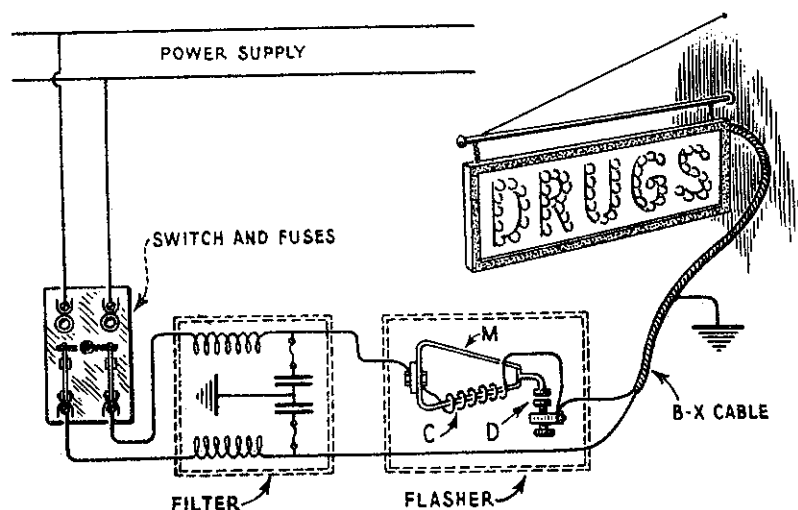


Figure 14

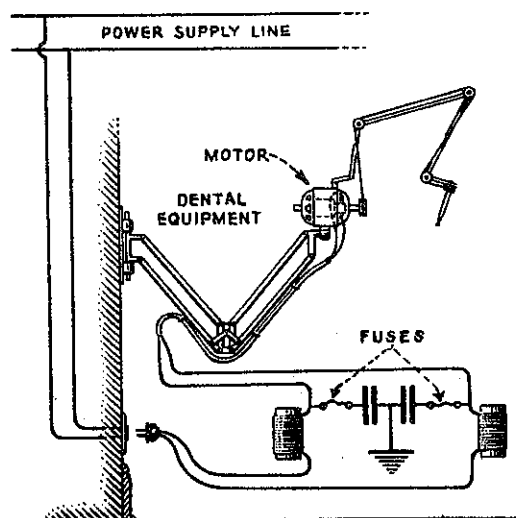


Figure 15

Dental motors often cause interference several hundred feet from their actual location. In cases of this kind one of the filter units of the type shown in Figures 5, 7, or 8 will usually clear the trouble. The condenser rating of the filter of Figure 5 should be at least 1.0 mfd. capacity, and of Figures 7 and 8, of 0.5 mfd. capacity. The choke coils should consist of 80 or 100 turns of No. 14 d.c.c. copper wire, lump wound on a 2 inch form. Such an installation is shown in Figure 15.

The operating electrical equipment of automatic oil burners often causes interference, and because no two may respond to the same treatment relative to the eliminating of radio interference, no specific remedies can be given. The general method of procedure, however, is available and is shown in Figures 16, 17, and 18. The transformer "T" is of the high tension type delivering in the neighborhood of 10,000 volts across the secondary which is used to ignite the vaporized oil as it is driven into the furnace. The condensers should be from 0.5 to 2.0 mfd. capacity. Choke coils consisting of

about 150 turns of No. 16 d.c.c. copper wire wound on a 2 inch form, lump wound, will have sufficient inductance. By lump wound is meant, wound without respect to any neat or orderly fashion as would be the case if wound single layer or bank wound.

X-ray Equipment. X-ray equipment, when consisting of a rectifier of the rotary synchronous type, will in practically all instances produce considerable radio interference which may be effective in either blotting out the broadcast signals entirely, or at least causing enough interference to make it very annoying. The best the service man can do in a case of this kind is to try out all the various types of filters until one is found that will materially reduce the interference. To eliminate all interference from machines of this type should not be expected by applying any combination of filter because a great proportion comes from the long high tension leads leading from the apparatus to the electrodes. The shielding of these leads, therefore, is not satisfactory because it interferes with their free use. The most practical method is to shield the entire room with a fine copper mesh, an expensive undertaking.

Motion Picture Equipment. The motor generator set employed to furnish power to the arcs of motion picture projection apparatus will sometimes cause interference for a distance of perhaps 300 yards. A filter of the type shown in Figure 5 will in most cases improve conditions. The condenser capacity should be at least 2.0 mfd. Connect the unit across the generator output as shown in Figure 19, protecting the generator from short circuiting or breaking down

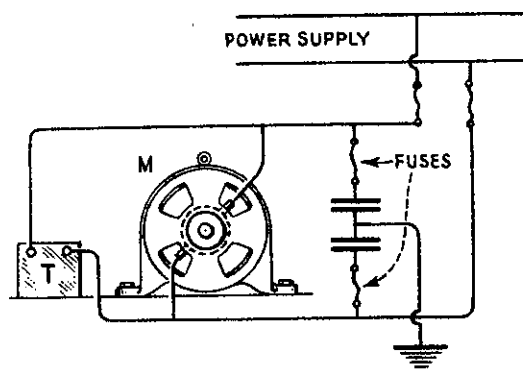


Figure 16

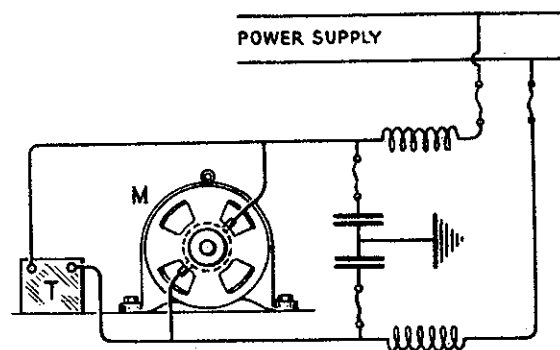


Figure 17

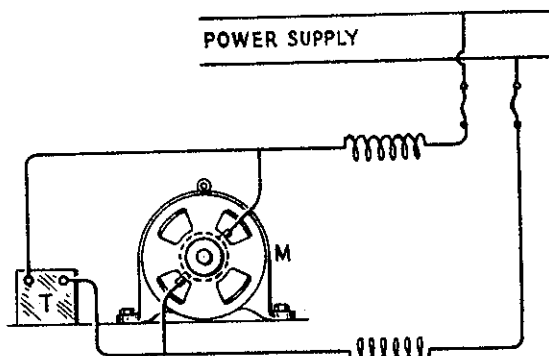


Figure 18

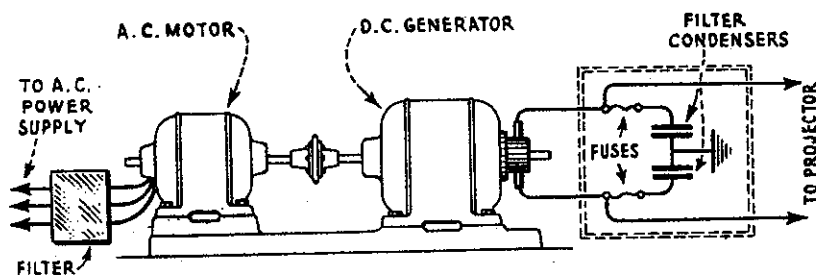


Figure 19

the condensers by inserting 5 ampere fuses in the filter circuit as shown. The filter unit should be enclosed in a metal box.

The filter shown in Figure 9 is called a "compound choke" and is sometimes successful when all of the other combinations fail. Usually, however, it will not be necessary to go to this extreme.

Figure 20 shows a filter connected in a three wire system. The choke coils must be large enough to carry the current to be drawn from the line. The condenser values may vary from 0.5 to 2.0 mfd. capacity and should be fused with 5 ampere fuses.

Figures 21 and 22 show possible sources of interference due to sparking when the iron is moved across the board. The remedy is to repair the defects by installing new parts or by making good soldered splices.

Power Lines. Lines carrying high potential are always a possible source of interference. The radio service man should never attempt to eliminate a suspected trouble on any high tension, power distribution, or traction line. The very first reason is that he is likely to pay for such work with his life. A power line carrying hundreds of thousands of volts is no respecter of persons and to attempt to tamper with it is extremely dangerous.

The second reason is that transmission lines of this kind are private property and persons not officially connected with the power company should never attempt to repair defective apparatus. Power and traction companies are always willing to cooperate with outside interests in running down troubles that are possible sources of interference. When radio reception is interrupted by some defect in power or traction systems, a complaint should be presented to the proper officials who are always glad to know of such defects as it means a loss of power (and consequently money) to the company.

As a matter of knowledge, however, it is well to know of conditions that contribute to the origination of radio interference and of the difficulty encountered in finding the cause of the trouble.

Traction Systems. Sources of inductive interference due to trolley, elevated, and subway traction lines are: Sparking commutator, sparking of motors driving the air compressors on the cars, sparking at the contactors of the controllers, faulty line insulators, and poor rail bonding. A long list could be written but this is sufficient to show the many possible sources.

Disturbances from any of the above causes create little or no interference close to their source, but the high frequencies generated in such cases may travel by means of the rails or power lines for considerable distances. In some localities, trolley and feeder wires often run parallel with telephone, telegraph, or light wires. High frequency impulses originating in the trolley and feeder wires transfer this energy by induction to the other lines parallel with them, and in this way the interference which started in one line may extend for great distances in other lines. It is conditions of this kind that make radio interference hunting sometimes "will-o'-the-wisp" and difficult to locate.

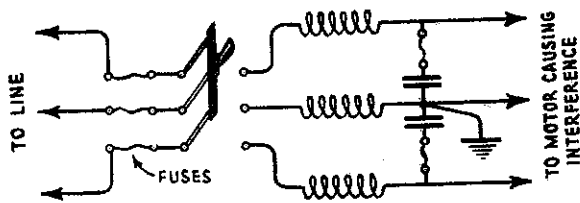


Figure 20

WORN AND LOOSE CONTACTS
CAUSE SPARKING EACH
TIME THE IRON IS MOVED
ACROSS THE IRONING BOARD

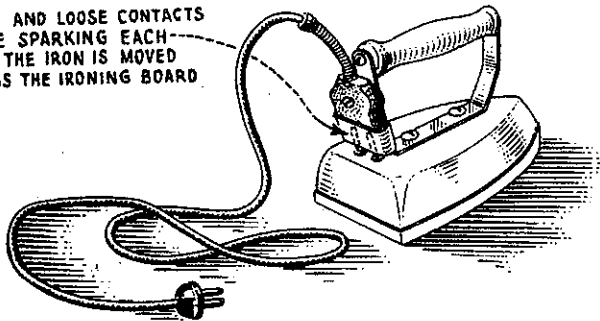


Figure 21

CONSTANT USE CAUSES STRANDS
OF FLEXIBLE WIRE TO BREAK AND
ARCING TAKES PLACE.

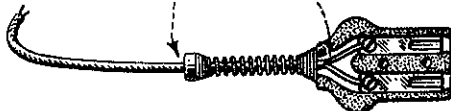


Figure 22

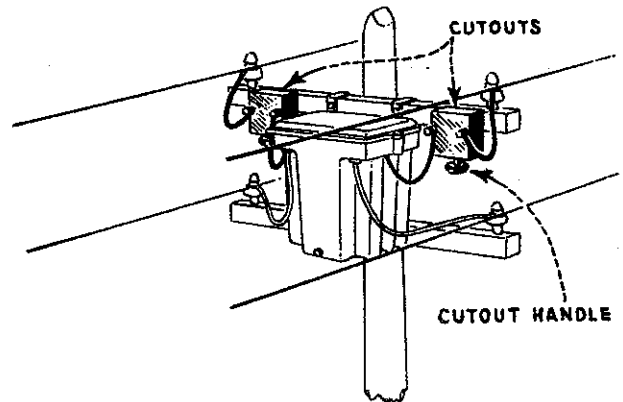


Figure 23

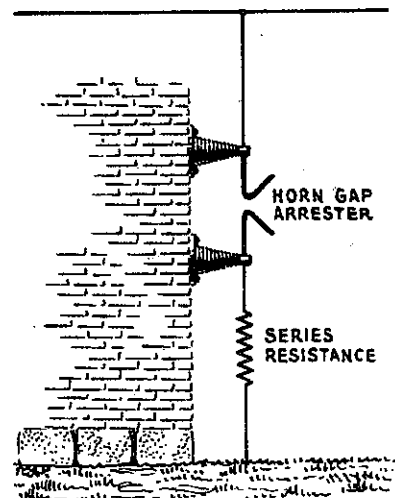


Figure 24

Spark discharges between the shaft and bearing through the oil film on rotary converters have been known to cause interference. This trouble was cleared by insulating the base or by making an electrical connection between the base and the shaft by means of a wiping contact. Examples of this kind are interesting because they serve to show the unlikely places that may be the source of radio interference.

Street Lighting. Defective lamp sockets, grounds caused by the power supply lines coming into contact with the branches of trees, especially in wet weather, and loose splices, are causes of radio interference.

Loose primary cut-outs of transformers often cause trouble. Figure 23 shows the general position of the cut-out in an actual installation. When good tight contact is not made by a cut-out, slight pole vibrations will cause slight interruptions in the current supply because of the bad cut-out. A condition of this kind will result in slight surges for great

distances either side of the defective unit. All lines parallel to the line in which the faulty part is connected will pick up this disturbance by induction and propagate it for miles.

The arcing to the transformer case from the primary leads of a high potential line produces a harsh buzzing sound from the loudspeaker. This is in many cases of such magnitude as to completely blot out broadcast reception for hours.

High Potential Systems. High voltage transmission lines contribute to the radio interference problems because of leaky condensers; also by heavy surges of current because of some faulty unit which, by induction, transfers the disturbance to other parallel systems causing interference for perhaps 20 miles from the source.

Horn-gap lightning arrestors shown in Figure 24 will discharge during snow and sleet storms, causing heavy clicking and snapping which has its effect on radio receivers.

From what has been said, it is realized that the elimination of radio interference, due to defective parts on power and traction lines, is to be undertaken only by men qualified to work on these systems.

Location of Trouble. We come now to the work of definitely locating the source of radio interference. In this work the assistance of broadcast listeners is often of great help in quickly locating the trouble.

For example, owners of sets who are experiencing excessive interference may often be requested by the power companies in their locality to keep a log of the time the interference begins, its characteristic sound, and the time it ceases, whether it comes in with a certain regularity, or only now and again. Information of this nature is very helpful in making a preliminary study of the situation before actual field work is begun. In a measure, it aids the men seeking the trouble to determine whether they will have to attack the problem from the standpoint of a fixed source from which the interference is being propagated, or because of transient phenomena.

After a study of the trouble has been made and it is definitely determined that the interference is originating from some operating equipment, a faulty unit, or from some electrical line outside of the building where the broadcast receiver is installed, tracing down the location is accomplished with the aid of an automobile and a portable loop receiver of good stable design.

The body of a closed car consists of considerable metal shielding and distortion of a signal results, hence an open car is preferred for this work.

The Receiver. Figure 25 shows a schematic diagram of a regenerative receiver suitable for tracing interference. The circuit consists of a loop antenna, a regenerative detector, and two stages of audio-frequency amplification. Regeneration and oscillation are produced in this circuit by means of the 0.00015 variable condenser. When this condenser is adjusted near its minimum position, regeneration is obtained. Advancing the adjustment of the condenser will, at a certain point, set the circuit into oscillation and it

then generates a high frequency alternating current. This high frequency combines with the incoming signal frequency, and a third frequency is produced. The resultant, or third frequency, is called a "beat current" which is made audible by adjustment of the 0.0005 variable condenser.

The loop has directional characteristics, that is, it will receive the greatest amount of signal energy when it points toward the source of the interfering signal. This idea is illustrated in Figure 26.

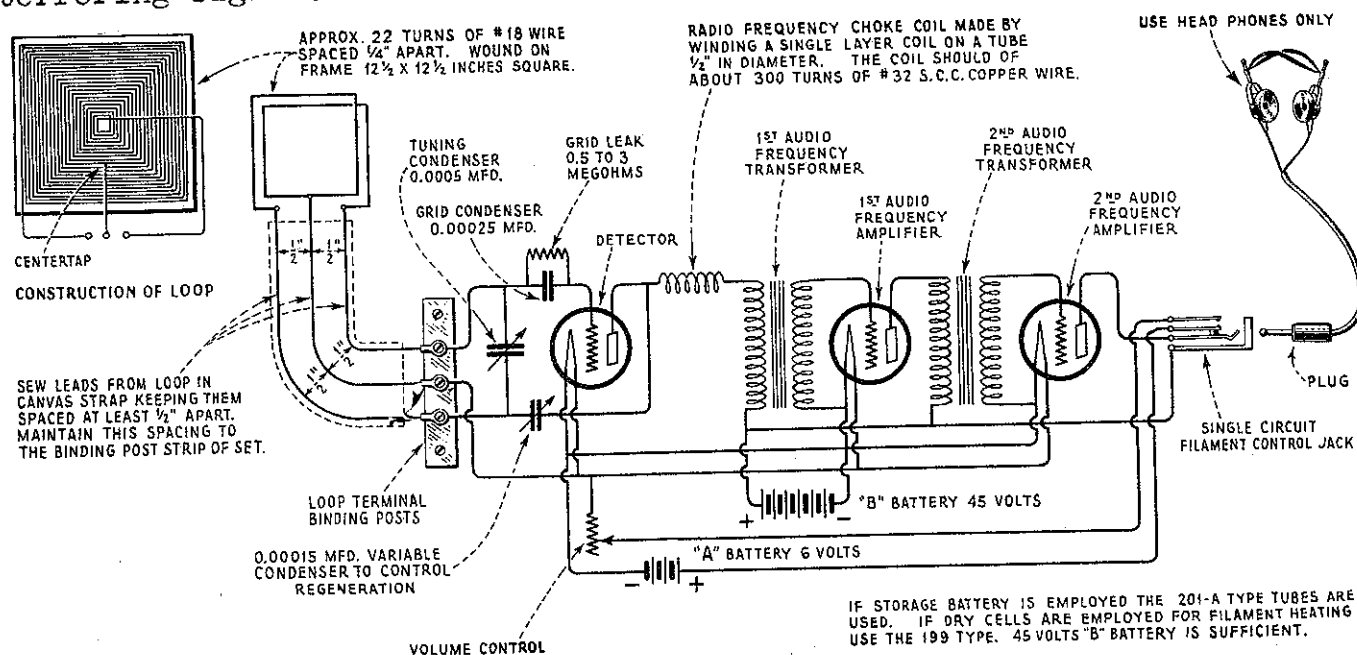


Figure 25

In the city the loop may show limited directional characteristics because of the net work of power, lighting, and traction feed wires. For this reason the location of interference is not accomplished by employing the directional characteristics of the loop, but by what is termed the "intensity of signal" method.

Starting from the building where the complaint is received, place the receiver in operation. Insert the headphone plug which automatically lights the filaments of the tubes. Turn the loop in a plane parallel with overhead power or lighting lines. Adjust the tuning control for maximum intensity, which may at times seem of equal intensity anywhere on the tuning dial. Reduce the volume control until the signal is barely audible and, without changing the position of the loop, proceed for a short distance along the line suspected of radiating the interference. Take another reading again, reducing the volume if possible which will indicate that the source of interference is nearer. This is continued until the volume control is reduced to its minimum setting. At this point the source of the trouble is usually found. If the location seems to indicate that the trouble is on a particular pole, it is then struck lightly in order that the wires or devices attached to it will vibrate. Poor connections or other defects will then make themselves known by spasmodic and irregular sounds in the headphones.

If at any time during the tracing of trouble, the filament or volume control has to be increased to make the signal audible, it is an indication that the receiver is being moved away from the source and not toward it, hence the only course to take is to move in the opposite direction.

A more sensitive equipment is desirable for this work at times, in which case a portable super-heterodyne receiver, such as shown in Figure 27, is employed.

The directional characteristics of a loop is not generally accepted to be the best method of locating faults that cause interference because of the fact that it will point to the nearest conductor which is carrying the disturbance even though the actual source may be located miles away.

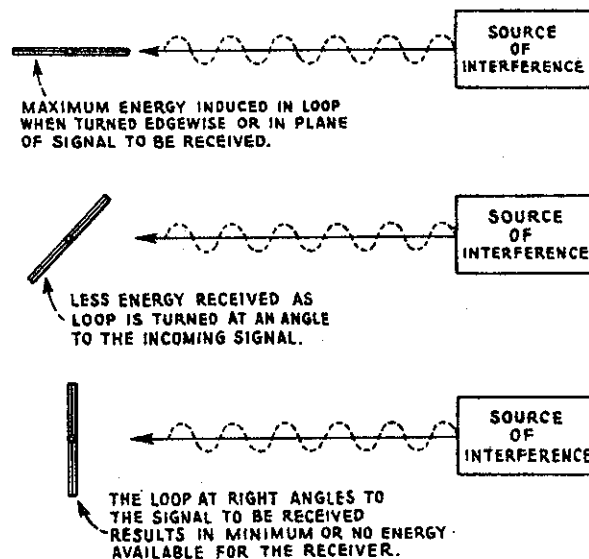


Figure 26

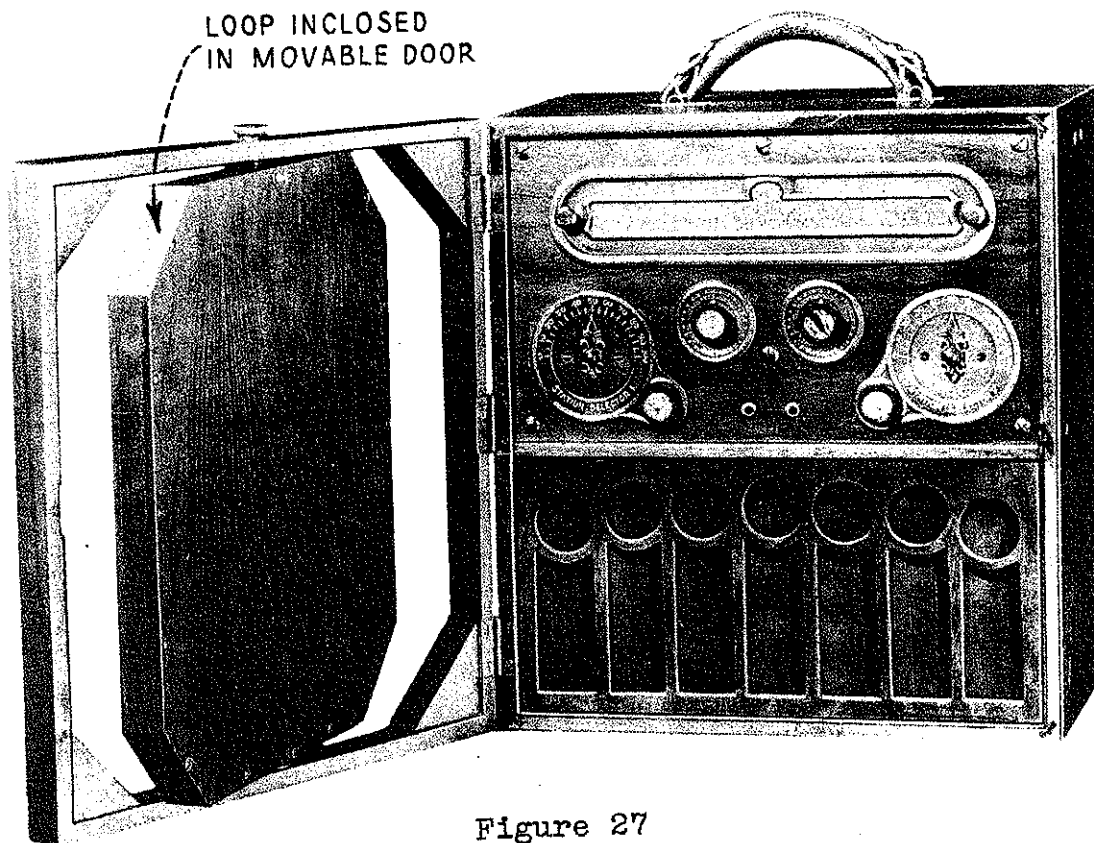


Figure 27

EXAMINATION - LESSON 55

1. What is meant by the term, "inductive interference?"
2. Draw a schematic diagram of a wave trap connected to a receiver.
3. Name some of the causes of static interference.
4. Under what conditions would you use a wave trap?
5. Just why are some receiving circuits more selective than others?
6. Describe a form of thermostatic control.
7. Draw a schematic diagram of a filter unit utilizing two condensers and one choke coil.
8. Name five sources of inductive interference.
9. (a) Why is it that a vacuum tube will cause a receiver to "howl?"
(b) What are some of the steps taken to overcome this?
10. What causes a receiver to oscillate?